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Use of NeuroXL Classofier to predict postoperative complications in patients with primary and postoperative ventral hernia in morbid obesity

The aim of the work: based on the use of the program of multiparametric neural network clustering to analyze the results of examination and surgical treatment of patients with primary and postoperative ventral hernia in morbid obesity to identify a group of patients with high risk of complications in the postoperative period.

Materials and Methods. A comprehensive clinical-instrumental and laboratory examination of 237 patients with primary ventral and postoperative ventral hernia with concomitant morbid obesity with subsequent assessment of the nature of complications in the early and late postoperative periods was conducted. Patients were examined according to standards with this nosology, including general clinical, detailed study of all organs and systems of the body and local status (location, size, length of hernial protrusion) according to the EHS classification (2009). In the postoperative period, early (prolonged lymphorrhea, seroma, hematoma, infiltrate, marginal necrosis of the skin, suppuration) and late (mesh migration, meshomas, intestinal and ligature fistulas, mesh rejection, chronic pain, hernia recurrence) local and general (abdominal compartment syndrome, pulmonary embolism, pneumonia, myocardial infarction) complications. Clustering of subjects by groups using the add-on NeuroXL Classifier for Microsoft Excel was conducted for more in-depth analysis and in order to predict the complications in the postoperative period

Results and Discussion. Analysis of cluster pictures during neural clustering based on clinical and anamnestic data and types of surgical interventions revealed that in predicting the risk of complications in the postoperative period based on combined changes, the combination of sex, obesity II-III and respiratory failure when own tissue hernioplasty and Onlay in patients were the most important. It should also be noted that the identified pattern primarily relates to the development of complications such as acute cerebrovascular accident, seroma and marginal necrosis of the postoperative wound. The lowest complication rate was observed in obese patients during laparoscopic hernioplasty and eMILOS (mini/less open sublay).

Key words: primary hernia; postoperative ventral hernia; obesity; neural network clustering; prognosis.

Problem statement and analysis of recent research and publications. Today, the issue of treatment of patients with primary ventral (PVH) and postoperative ventral hernia (POVH) remains one of the pressing problems of abdominal surgery [1, 2]. The increase of abdominal hernias incidence and the number of complications in the postoperative period are associated with an increase in the number of patients with morbid obesity, who are at particular risk for the incidence of complications after surgery [3, 4]. In Ukraine, 28.5 % of the total population are obese, 48 % are overweight. Most surgeons have different views on the treatment of these patients. No individualized approach to each patient, does not take into account its probable factors of hernia development, comorbidities, lack of sufficient experience and skills in choosing the optimal method of surgery lead to unsatisfactory treatment results [5]. Despite a significant number of surgical techniques of abdominal wall correction, the results of surgical treatment of ventral and postoperative ventral hernias are unsatisfactory, as evidenced by the large number of complications and high recurrence rate (4.5–42 %). The morbid obesity in a patient can significantly change the course of the postoperative period and affect its prognosis [6].

The use of modern information programs greatly facilitates the solution of problems in predicting the complications in the postoperative period. Currently, neural networks are widely used to predict complications [7–12].

The aim of the work: based on the use of the program of multiparametric neural network clustering to analyze the results of examination and surgical treatment of patients with primary and postoperative ventral hernia in morbid obesity to identify a group of patients at high risk of complications in the postoperative period.

Materials and Methods. An in-depth comprehensive clinical-instrumental and laboratory examination of 237 patients with primary ventral and postoperative ventral hernia with concomitant morbid obesity was performed, followed by assessment of the nature of complications in the early and late postoperative periods. The study was conducted on the basis of the Department of Surgery of the Faculty of Postgraduate Education of I. Horbachevsky Ternopil National Medical University in the Surgical Department of Ternopil City Municipal Hospital No. 2 during 2019–2021. Obese patients with PVH and POVH

were examined according to standards with this no-sology, including general clinical, detailed study of all organs and systems of the body and local status (location, size, length of hernial protrusion) according to the EHS classification (2009). All patients underwent body mass index (BMI) determination and individual risk assessment of venous thromboembolic complications according to J. Caprini (2005).

There were 179 women (75.62 %) and 58 men (24.38 %). There were 36 (15.18%) patients aged 20–44, 111 (46.78%) – aged 45–60, 90 (38.04 %) – aged 61–75. The predominance of primary and postoperative ventral hernias of the middle location was 90.99 %. M1 defects were found in 6.81 %; M1-3 – 69.38 %; M3 – in 11.21 %, M4–5 – 3.59 %; L1, L2, L4 – 2.14 % of cases. Combined ML defects were in 6.87 % of patients. In the postoperative period, early (prolonged lymphorrhea, seroma, hematoma, infiltrate, marginal necrosis of the skin, suppuration) and late (mesh migration, meshomas, intestinal and ligature fistulas, mesh rejection, chronic pain, hernia recurrence) local and general (abdominal compartment syndrome, pulmonary embolism, pneumonia, myocardial infarction) complications were assessed. BMI was used to assess overweight. According to BMI, overweight is established when it is bigger than 25. The distribution of obese patients according to BMI is shown in Table 1. As can be seen, almost half of patients (107 (45.16%)) have class II obesity.

Table 1. BMI in obese patients (n=237).

BMI	Number of patients, % (n=237)
25–30	76 (32.07)
30–35	107 (45.15)
35–40	54 (22.78)
40 and more	–

The distribution of obese patients by age is shown in Table 2. Most patients with obesity of different classes were observed at the age of 45–60 – 111 (46.78 %).

According to our study patients aged over 45 were observed to have the main increase in body weight. Moreover, men begin to gain weight after about 40, and women – on average after 45–50. Henceforth, there is a tendency to increase body weight with age (average age in the group with obesity class I – (48.34±0.97), class II – (65.70±0.85), class III – (53.48±0.73)), but without significant age differences.

Obese patients are at the highest risk of anesthesia and surgery, as about 65–80 % of them are not examined at the time of hospitalization. At the same time, as the patient prepares for planned surgery, up to 3–4 comorbidities are detected.

Results and Discussion. Laboratory indicators and anamnesis

In order to establish the value of combined changes in the studied indicators for effective prediction of complications, neural network clustering of the results of a comprehensive clinical history and laboratory studies was performed based on the following indicators: age, sex, blood type, comorbidity: Age – age (1), S – sex (2), Ob – obesity I, II, III (3), CPI – chronic obstructive pulmonary disease (4), HeF – heart failure (5), Diab – diabetes mellitus (6), NDS – undifferentiated connective tissue dysplasia (7), VD – varicose vein disease (8), protein (10), bilirubin (11), creatinine (12), urea (13), AST (14), ALT (15), types of surgeries performed and complications of postoperative period (a total of 34 indicators). The indicator C was also determined for each patient as "1" in the absence of complications and "2" – their presence in the postoperative period.

Three clusters were selected for the neural network clustering algorithm. Figure 1 shows the results of the program clustering indicators. Cluster 1 includes 45.09 % of patients, cluster 2 – 29.91 %, and cluster 3 – 25.00 %.

Table 2. Distribution of patients by class of obesity and age

Obesity class	Aged 20–44 (n=36)		Aged 45–60 (n=111)		Aged 61–75 (n=90)		Total (n=237)	
	abs.	%	abs.	%	abs.	%	abs.	%
I	18	50.00	39	35.14	19	21,11	76	32,07
II	9	25.00	45	40.54	53	58,89	107	45.15
III	9	25.00	27	24.32	18	20.00	54	22,78

Table 3. Distribution of patients with obesity by type of surgery by age

Type of surgery	Obesity class							
	Obesity class I (n=76)		Obesity class II (n=107)		Obesity class III (n=54)		Total (n=237)	
	abs.	%	abs.	%	abs.	%	abs.	%
Own tissue hernia repair	21	27.63	17	15.88	7	12.96	45	18.98
Onlay	3	3.94	9	8.42	2	3.70	14	5.91
Inlay	1	1.33	4	3.74	-		5	2.11
Sublay	27	35.53	31	28.97	26	48.15	84	35.44
CST + mesh	2	2.63	2	1.87	1	1.85	5	2.11
Laparoscopic hernia repair	6	7.89	19	17.76	14	25.00	39	16.46
eMILOS (mini/ lessopensublay)	16	21.05	25	23.36	4	7.5	45	18.99
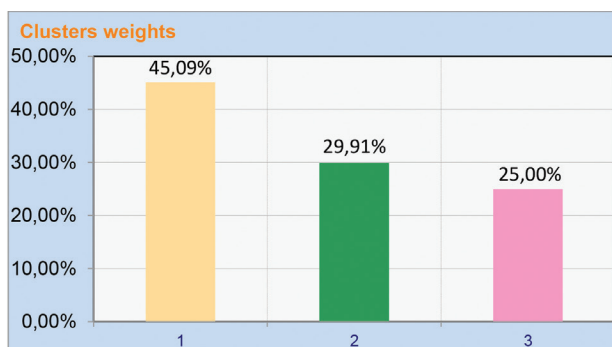
Fig. 1. Percentage of patients enrolled in a particular cluster.
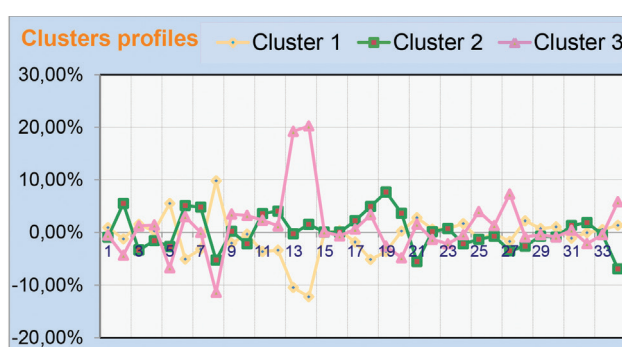
Fig. 2. Cluster picture – the values of parameters, including clinical history and laboratory parameters and the rate of complications in the postoperative period

As shown in Figure 2, the value of the complication rate in the postoperative period (34) was higher in cluster 3. Using a cluster picture, we can determine that this cluster had the highest rates of respiratory failure (4), protein levels (9), total bilirubin (10), urea (13) and AST (14). Among the postoperative complications, myocardial infarction (25), acute cerebrovascular accident (26) and suppuration of the postoperative wound (27) were more common in cluster 3.

In order to establish the value of the combined changes of certain parameters to predict the occurrence of complications, a neural network clustering of the results of clinical and anamnestic examination and types of surgical interventions was performed on the basis of a number of indicators. In order to establish the value of combined changes of parameters for the prognosis of ventral hernia complications, neural network clustering of patients' results was performed

based on gender indicators, types of surgical interventions (2–10), early (11–16) and late (23–25), complications on the wound, as well as general (17–22) complications: s – sex (1), PH – primary ventral hernias (2), AHP – own tissue hernia repair (3), On – onlay (4), In – inlay 5), Sub – sublay (6), CST – separation hernia repair (7), DLE – dermatolipectomy (8), laparoscopic hernia repair (9), eMILOS (mini/less open sublay) (10), Lym – lymphorrhea (11), Ser – seroma (12), Hem – hematoma (13), Sub – suppuration (14), LF – ligature fistulas (15), En – marginal necrosis (16), TELA – pulmonary embolism (17), ACS – abdominal compartment syndrome (18), Pneum – pneumonia (19), Inf – myocardial infarction (20), Stroke – stroke (21), MM – mesh migration (22), MC – mesh cysts (23). The indicator C was also determined for each patient as "1" in the absence of complications and "2" – their presence in the postoperative period.

The parameters proposed by the program and three clusters were selected for the neural network clustering algorithm. Figure 3 shows the results of the program clustering indicators. Cluster 1 includes 25.00 % of patients, cluster 2 – 29.91 %, and cluster 3 – 45.09 %.

As can be seen in Figure 4, the value of the complication rate in the postoperative period (23) was higher in cluster 1. With the help of a cluster picture, it can be determined that cluster 1 also had the highest rates of gender (1), obesity II–III (3) and respiratory failure (4). In this group, among the postoperative complications, acute cerebrovascular disorders (15), seroma (16) and marginal necrosis (17) of the postoperative wound were more common.
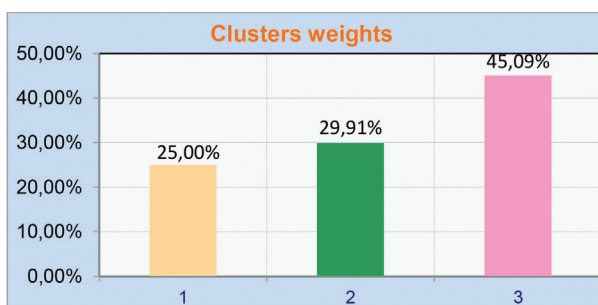
Fig. 3. Percentage of patients enrolled in a particular cluster.
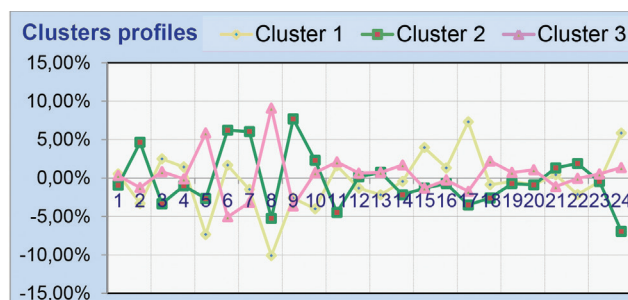
Fig. 4. Cluster picture – the value of parameters, including clinical and anamnestic indicators and the rate of complications in the postoperative period.

Conclusions. Analysis of cluster pictures in neural network clustering based on clinical history and laboratory indicators and the rate of complications in the postoperative period revealed that in predicting the risk of complications in the postoperative period based on the combined changes in the anamnesis, the most significant are the combination of sex, respiratory failure and elevated levels of protein, total bilirubin, urea and AST in the operated patients. The revealed regularity first of all concerns development of such complications as a myocardial infarction, acute disturbance of cerebral circulation and suppurations of a postoperative wound.

Analysis of cluster pictures during neural network clustering based on clinical and anamnestic data and types of surgical interventions revealed that in predicting the risk of complications in the postoperative period based on combined changes, the most important are the combination of sex, obesity II–III and respiratory failure when performing own tissue hernioplasty and Onlay in patients. It should also be noted that the identified pattern primarily relates to the development of complications such as acute cerebrovascular accident, seroma and marginal necrosis of the postoperative wound. The lowest complication rate was observed in obese patients during laparoscopic hernia repair and eMILOS (mini/less open sublay).

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ОРИГІНАЛЬНІ ДОСЛІДЖЕННЯ

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ВИКОРИСТАННЯ ПРОГРАМИ "NEUROXLCLASSIFIER" З МЕТОЮ ПРОГНОЗУВАННЯ УСКЛАДНЕНЬ У ПІСЛЯОПЕРАЦІЙНОМУ ПЕРІОДІ В ПАЦІЄНТІВ НА ПЕРВИННУ ТА ПІСЛЯОПЕРАЦІЙНУ ВЕНТРАЛЬНУ ГРИЖУ ЗА УМОВ МОРБІДНОГО ОЖИРІННЯ

Мета роботи: на основі використання програми багатопараметричної нейромережевої кластеризації проаналізувати результати обстеження та хірургічного лікування пацієнтів на первинну та післяопераційну вентральну грижу за умов морбідного ожиріння для виділення групи пацієнтів із високим ступенем ризику виникнення ускладнень в післяопераційному періоді.

Матеріали і методи. Проведено комплексне клініко-інструментальне та лабораторне обстеження 237 пацієнтів на первинну вентральну та післяопераційну вентральну грижу із супутнім морбідним ожирінням з подальшим оцінюванням характеру ускладнень у ранньому та пізньому післяопераційному періодах. Обстеження пацієнтів проводили відповідно до стандартів із даною нозологією, включно загальноклінічні, детального дослідження стану всіх органів і систем організму та локального статусу (локалізації, розмірів, протяжності грижового випинання) відповідно до класифікації EHS (2009). У післяопераційному періоді оцінювали ранні (тривала лімфорея, серома, гематома, інфільтрат, крайовий некроз шкіри, нагноєння) та пізні (міграція сітки, мешоми, кишкові та лігатурні нориці, відторгнення сітки, хронічний біль, рецидив грижі) місцеві і загальні (абдомінальний компартмент-синдром, тромбоемболія легеневої артерії, пневмонія, інфаркт міокарда) ускладнення. Для більш глибокого аналізу та з метою прогнозування виникнення ускладнень в післяопераційному періоді проведено кластеризацію досліджуваних по групах із використанням надбудови NeuroXL Classifier для програми Microsoft Excel.

Результати досліджень та їх обговорення. Аналіз кластерних портретів при проведенні нейромережевої кластеризації на основі клініко-анамнестичних даних та типів проведених операційних втручань виявив, що при прогнозуванні ризику ускладнень у післяопераційному періоді на основі поєднаних змін найсуттєвіше значення мають поєднання статі, ожиріння II-III та дихальної недостатності при виконанні власнетканинної герніопластики та Onlay у пацієнтів. Треба також зазначити, що виявлена закономірність насамперед стосується розвитку таких ускладнень, як гостре порушення мозкового кровообігу, серома і крайовий некроз післяопераційної рани. Найнижчий показник ускладнень спостерігали в пацієнтів з ожирінням при виконанні лапароскопічної герніопластики та eMILOS (mini/less open sublay).

Ключові слова: первинна грижа; післяопераційна вентральна грижа; ожиріння; нейромережева кластеризації; прогнозування.